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Atomic hydrogen masers are being used to measure the shift of the atomic hydrogen hyperfine frequency with applied electric field. Hydrogen masers are also being used to measure the hyperfine structure of atomic nitrogen including the atomic magnetic moment, the magnetic dipole interaction between the nucleus and the electrons, and the nuclear electric quadrupole interaction. Both N^{14} and N^{15} will be studied. Hydrogen maser improvements are also being developed and tested. The photodetachment spectrum of S^- in a magnetic field has also been studied.

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SUMMARY OF PROPOSAL FOR CONTINUATION OF HYDROGEN MASER AND STORED ATOM RESEARCH AT HARVARD UNIVERSITY

SUMMARY

1. Contract Description

Atomic hydrogen masers are being used to measure the shift of the atomic hydrogen hyperfine frequency with applied electric field. Hydrogen masers are also being used to measure the hyperfine structure of atomic nitrogen including the atomic magnetic moment, the magnetic dipole interaction between the nucleus and the electrons, and the nuclear electric quadrupole interaction. Both N^{14} and N^{15} will be studied. Hydrogen maser improvements are also being developed and tested. The photodetachment spectrum of S^- in a magnetic field has also been studied.

2. Scientific Problems

The previous measurements of the shift of the atomic hydrogen hyperfine frequency with electric field has large experimental errors and appeared to disagree with theory beyond the estimated error; new measurements are needed to determine if this disagreement is of a fundamental nature. The preliminary value for the nuclear electric quadrupole interaction in N^{14} is about a million times smaller than the smallest non-zero quadrupole interaction ever seen in any other atom and is also about twenty times smaller than the best theoretical predictions at the time the research was started; a recent improved theoretical calculation has lowered the predicted value closer to our preliminary experimental result. The accuracy of the electric quadrupole interaction as well as the magnetic interaction measurements should be considerably improved in the continuation of the experiment. In the photodetachment studies, an unexpected spectral structure was found.

3. Scientific and Technical Approach

A hydrogen maser with the storage region being the space between the two concentric cylinders has been developed. An electric field is then applied between the two cylinders and the shift in the hydrogen maser signal is observed. In the N^{14} and N^{15} studies, the nitrogen atoms are introduced into an operating hydrogen maser and a partial quenching of the maser oscillations due to spin exchange collisions between the hydrogen and nitrogen is observed. The effectiveness of this quenching depends on the hyperfine state of the nitrogen so the nitrogen hyperfine spectrum is observed by sweeping the frequency of an oscillatory magnetic field through appropriate values while transitions are detected by changes in the magnitude of the maser oscillations. The photodetachment spectra for S^- ions are observed by shining laser light on S^- ions in a Penning trap (uniform magnetic field but non uniform electrostatic trapping field).

4. Progress

The experiment on the electric field shift of the hydrogen hyperfine frequency has worked well. Except for possible further calibration corrections, the value for the coefficient $\alpha_\perp = (7.56 \pm 0.26) \times 10^{-5}$ Hz/esu^2, in good agreement with the present best theoretical value 7.41×10^{-5} Hz/esu^2. A paper on the magnetic moment of atomic nitrogen has been published. The maser is being modified to increase the nitrogen flux. An unexpected structure has been observed and interpreted in the photodetachment spectra and papers on it have been published.

5. Publications

(a) J. M. Hirsch, G. H. Zimmerman, III, D. J. Larson and N. F. Ramsey, Phys. Rev. A16, 484 (1977).

(b) W. A. M. Blumberg, R. M. Jopson, and D. J. Larson, Phys. Rev. Letters 40, 1320 (1978).

(c) Several completed but not yet published manuscripts.

6. Extenuating Circumstances

Professor D. J. Larson left this fall for a tenured position at the University of Virginia.

7. Personnel

Professor N. F. Ramsey

Associate Professor D. J. Larson

Dr. J. Stuart

Mr. G. H. Zimmerman

Mr. W. Blumberg

Mr. R. Jopson

8. Dr. James Stuart has just received his Ph.D. for his research supported by this contract. Mr. W. Blumberg has completed the research for his thesis, but has not yet written his thesis.